Pests in Stored Products

by R. T. COTTON

NTIL RECENTLY the only really effective insecticides available for controlling insect pests of grains and food products stored in bulk or packages were those that could be used in the vapor stage as fumigants. Contact sprays did little good. Insects harbored in the woodwork of farm and elevator grain bins, warehouses, storerooms, flour mills, ships, and railway cars are not readily controlled by fumigation, and constitute a source of infestation whose importance to our food industries can scarcely be overestimated. Newly harvested grain placed in wooden bins, boxcars, warehouses, and such quickly becomes infested with insects that emerge from the cracks in walls and floors.

Now the so-called residual spray has assumed an important role in the control of these pests. The residual spray, when applied to the surface of walls, floors, partitions, et cetera, leaves a protective film of a toxic chemical that causes the death of insects that touch it.

Several chemicals with residual properties have been developed, many of them highly effective against the insect pests of stored grain and milled cereals. The best known is DDT, which can be had in many different forms and concentrations, and can be used in either a water or an oil-base spray. Two analogs of DDT, which possess quite similar characteristics, are di(paramethoxyphenyl) trichloroethane and dichlorodiphenyl-dichloroethane. Other residual chemicals are a chlorinated campene with the empirical formula $C_{10}H_{10}Cl_8$, and a chlorinated hydrocarbon, with the empirical formula $C_{10}H_6Cl_8$.

A 5-percent concentration of any one of the first four compounds or a 2-percent concentration of the last in a deodorized kerosene are highly effective against even the most resistant type of stored-product insect. They should be applied at the rate of not more than 1 gallon per 1,000

square feet of surface area. These residual poisons are relatively slow in action. The addition of a "knock-down" agent, such as pyrethrum or one of the thiocyanates, improves the efficiency of their performance.

Because all the residual insect toxicants are poisonous to warm-blooded animals, they must not be used to spray grain or milled cereal products intended for human food or animal feed. Precautions must also be taken to avoid spraying food containers and to prevent foodstuffs from coming into direct contact with sprayed surfaces.

DDT may also be useful for incorporation into wrappers for preventing the entry of insects into bagged and packaged foodstuffs. The adaptation of DDT to this use is still in the experimental stage, but it shows promise of being invaluable for the purpose of protecting many types of susceptible foodstuffs from invasion by insects after manufacture and packaging.

As a dust, DDT has been found highly efficient in protecting bagged and packaged seed from insect attack and provides one of the cheapest and best methods of long-time protection known. Effective when mixed with seed at the rate of only 15 parts per million, it is best used in combination with a carrier dust. The carrier, by increasing the volume, insures a better distribution over the seed. Dust composed of 3 percent of DDT in magnesium oxide or pyrophyllite has been found satisfactory, although any commercially available dust containing 3 percent DDT can be used.

DDT dust of this concentration should be applied at the rate of a half ounce to a bushel of seed. Seed-treating machines can be used efficiently to coat the seeds with a uniform layer of the protective dust. The treatment does not affect germination in any way. DDT is a chemically active dust that kills insects by contact, so it is effective regardless of the moisture content of the seed.

Certain chemically inactive dusts have also been found useful for protecting seed. Their effectiveness is thought to be due to their abrasive action that breaks the waterproof, fatty covering of insects, so that the insects die as a result of the evaporation of excessive amounts of body moisture. Because of their mode of action, the effectiveness of inert dusts decreases as the moisture content of the seed rises above 12 percent.

Of numerous chemically inert dusts that we have tested, we found magnesium oxide especially good for protecting seed from insects. It is a nonpoisonous dust used medicinally in cases of stomach acidity. Many types of magnesium oxide are available on the market, and extensive laboratory tests have shown that those having a particle size of 1 micron or less afford excellent protection when mixed, at the rate of 1 ounce to the bushel, with seed containing not more than 12 percent moisture. In general, the finer the dust the more effective it is. Besides its killing effect, magnesium oxide has a repellent property, and seeds treated with it are rarely invaded by insects; besides, it is inexpensive and gives a clean and attractive appearance to seed.

The gamma isomer of benzene hexachloride is reported to be highly effective in extremely small quantities against some types of stored-product insects and may prove to be a useful insecticide in combating them. Supplies now available commercially have a bad smell that will have to be eliminated before it will be suitable for use in protecting foodstuffs. The fact that it is poisonous to warm-blooded animals will also have to be considered carefully in connection with its possible use in foodstuffs. As an insecticide benzene hexachloride has the merit of acting not only as a stomach poison but as a contact agent and as a fumigant.

Fumigants

Many new compounds are proving to be useful for fumigating mills, warehouses, and granaries to kill insects. Methyl bromide has outstanding value for treating bulk commodities in vaults, boxcars, and warehouses. Because it is sorbed to a lesser extent than other fumigants in common use, it easily penetrates bulk commodities and can be successfully used at relatively low concentrations. In airtight enclosures, dosages of 1 to $1\frac{1}{2}$ pounds per 1,000 cubic feet of space are generally satisfactory at temperatures of 60° F. or above. At temperatures below 60° F. the dosage should be increased a half pound per 1,000 cubic feet of space for every 5° drop in temperature.

In recent work on the fumigation of wheat in tightly calked steel bins, it was found that some fumigants are retained by the wheat for unusually long periods; their insecticidal action, therefore, lasts much longer than one would ordinarily expect. Because of this phenomenon, we can use successfully fumigants that once were considered too low in toxicity to be of practical value. Carbon tetrachloride, long used in admixture with flammable chemicals to reduce the fire hazard and with more toxic compounds to increase volume and aid in uniformity of distribution, is being used alone with excellent results at dosages of 3 gallons per 1,000 bushels. At the end of exposure lasting a week, consistently high kills of all stages of grain-infesting insects are obtained.

A mixture of three parts of ethylene dichloride and one part of carbon tetrachloride when applied to wheat in steel bins at the rate of 4 gallons to 1,000 bushels may be retained in killing concentration for as long as 4 months. Applied to wheat bins in Kansas in late August or early September, it protects the grain from insects that migrate to the bins during the rest of the summer and fall.

For fumigating wheat or corn in steel bins, methyl bromide in combination with various chemicals or combinations of chemicals is highly effective. A dosage of 2 gallons per 1,000 bushels of wheat or corn of the following mixtures gives a consistently good kill: Methyl bromide,

10 percent by volume mixed with carbon tetrachloride or ethylene dichloride or methylene chloride or propylene dichloride; or a 3-to-1 mixture of ethylene dichloride and carbon tetrachloride; or a 3-to-1 mixture of propylene dichloride and carbon tetrachloride.

Other fumigants effective for treating grain in steel bins are B-methylallyl chloride and 1,1-dichloro-1-nitroethane. Two pounds of B-methylallyl chloride in sufficient carbon tetrachloride to make 1 gallon can be used at the rate of 2 gallons per 1,000 bushels for wheat or corn, and 1 pound of 1,1-dichloro-1-nitroethane in sufficient carbon tetrachloride to make 1 gallon can be used at the rate of 1 gallon per 1,000 bushels of corn or $1\frac{1}{2}$ gallons per 1,000 bushels of wheat.

Ethylene dibromide, suggested as a possible grain fumigant by I. E. Neifert and associates in the Department, has recently become available in commercial quantities. A mixture of one part by volume of ethylene dibromide to nine parts of carbon tetrachloride gives a satisfactory kill of insects in stored wheat at dosages of 2 gallons of the mixture per 1,000 bushels in steel bins, and at 4 gallons per 1,000 bushels in wooden farm bins. Because a considerable part of the ethylene dibromide is sorbed by the wheat near the surface of the bin, the mixture is admirably suited for the treatment of wooden bins in which it is hard to kill the insects in the surface grain.

Of a number of nitriles (organic cyanides) tested as possible grain fumigants, 2-chloroacrylonitrile and 2-chloroacetonitrile compare favorably in toxicity with acrylonitrile and trichloroacetonitrile. In admixture with carbon tetrachloride at the rate of one part by volume of the nitrile to nine parts of carbon tetrachloride, both compounds were found to be highly toxic to insects in wheat stored in tight steel bins, when used at the rate of 1 gallon per 1,000 bushels. A mixture composed of 5 percent by volume of 2-chloroacrylonitrile, 5 percent 2,2,3-trichlorobutyronitrile, and 90 percent carbon tetrachloride, used at the rate of 1 gallon per 1,000 bushels of wheat, proved to be superior in performance to the other combinations I have mentioned. The compounds 2-chloroacrylonitrile and 2-chloroacetonitrile should be handled carefully to avoid spilling the liquid on clothing or skin or exposing the perspiring body to the vapors, because severe skin irritation may result from such exposure.

For the spot fumigation of milling units in flour mills, mixtures of equal parts by volume of acrylonitrile and carbon tetrachloride and 15 parts by volume of ethylene dibromide in 85 parts of carbon tetrachloride have been found effective. In flour mills insect infestation is more or less concentrated in the milling machinery wherever milling stock accumulates and is relatively undisturbed. The application of a fumigant to the milling units every 3 or 4 weeks will hold the insect population in a flour mill to a low level at all times.

Individual-package fumigation with ethyl or methyl formate has been

practiced in the dried-fruit industry for many years. More recently isopropyl formate has come into use for the purpose, and the method has been adapted for the treatment of other food products. In treating packages of pea soup stock, 1 cubic centimeter of isopropyl formate is injected into stout paper bags holding 5 pounds of the soup stock. The bag is then heat-sealed in two transparent viscose bags. This method of fumigation should increase in popularity for treatment of high-priced commodities.

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FOR FURTHER READING

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